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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	DYNAMICS
COURSE CODE	:	BDA 20103
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	PART A (OPTIONAL): ANSWER **ONE (1)** QUESTION **ONLY** PART B (COMPULSORY): ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

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PART A (OPTIONAL):
ANSWER ONE (1) QUESTION ONLY.

Q1. (a) Briefly explain two parameters usually used in the kinematics analysis of a particle.

(4 marks)

(b) At the instant as shown in **Figure Q1(b)**, the bicyclist at A is traveling at 7 m/s around the curve on the race track while increasing his speed at 0.5 m/s^2. The bicyclist at B is traveling at 8.5 m/s along the straight-a-way and increasing his speed at 0.7 m/s^2. At this instant, determine:

(i) the relative velocity of A with respect to B.

(8 marks)

(ii) the relative acceleration of A with respect to B

(8 marks)

Q2. **Figure Q2** shows a 0.015 kg bullet which is travelling at the speed of $400\,\text{m/s}$. The bullet strikes the 5 kg wooden block and then exit the other side of the block at $15\,\text{m/s}$. The coefficient of kinetic friction between the block and surface is $\mu_K = 0.5$.

(i) Determine the speed of the block just after the bullet exit the block.

(8 mark)

(ii) Find the average normal force on the block if the bullet passes through it in $1\,\text{ms}$.

(8marks)

(iii) Calculate the time the block slides before it stops.

(4 marks)

PART B (COMPULSORY):
ANSWER ALL QUESTIONS.

Q3. (a) In **Figure Q3(a)**, the driving gear A and the driven gear B will always turn in opposite directions. In order to get them to turn in the same direction, an idler gear C is used. In the case shown, calculate the angular velocity of gear B when $t = 5$ s, if gear A starts from rest and has an angular acceleration of $\alpha_A = (3t + 2)$ rad/s^2, where t is in seconds.

(6 marks)

(b) In **Figure Q3(b)**, gears A, B, C, and D have radii of 15 mm, 50 mm, 25 mm, and 75 mm, respectively. If gear A rotates with a constant angular acceleration of $\alpha_A = 90$ rad/s^2 starting from rest,

(i) calculate the time required for gear D to attain an angular velocity of 600 rpm.

(8 marks)

(ii) calculate the number of revolutions of gear D to attain same angular velocity.

(6 marks)

Q4. (a) The bar AB of the linkage shown in **Figure Q4(a)** has a clockwise angular velocity, $\omega = 30$ rad/s when $\theta = 60^\circ$. Using the instantaneous centers of zero velocity, determine the angular velocities, ω (magnitude and direction) of members BC and the wheel CD at this instant.

(5 marks)

(b) At the instant shown in **Figure Q4 (b)**, link AB has an angular velocity, $\omega_{AB} = 2$ rad/s and an angular acceleration, $\alpha_{AB} = 6$ rad/s^2. At instant $\theta = 60^\circ$, determine

(i) the magnitude and direction of acceleration at pin B, a_B m/s^2

(2 marks)

(ii) the angular velocity of link BC, ω_{BC} rad/s and link CD, ω_{CD} rad/s

(4 marks)

(iii) the angular acceleration of link CB, α_{CB} rad/s^2

(5 marks)

(iv) the angular acceleration of link CD, α_{CD} rad/s^2

(4 marks)

Q5. (a) The disk as shown in **Figure Q5 (a)** has a mass of 20 kg and is originally spinning at the end of the strut with an angular velocity of ω = 60 rad/s. If it is then placed against the wall, where the coefficient of kinetic friction is $\mu_k = 0.3$,

(i) calculate the force in strut *BC* during this time

(7 marks)

(ii) determine the time required for the motion to stop

(3 marks)

(b) A 40-kg block *C* is supported by a 20-kg cylinder *A* and a 30-kg cylinder *B* as shown in in **Figure Q5(b),** where the cylinders have the same radius r =100 mm. The system is at rest at the time $t = 0$ when a 50-N force **P** is applied to the block *C*.

(i) Draw the impulse diagram and final momentum diagram for the entire system.

(2 marks)

(ii) Draw the impulse diagram and final momentum diagram for cylinder *A*.

(2 marks)

(iii) Draw the impulse diagram and final momentum diagram for cylinder *B*.

(2 marks)

(iv) If the cylinders roll without slipping, determine the velocity v_C of the block *C* at the time $t = 2$ s.

(4marks)

Q6. **Figure Q6** shows the disk which has a mass of 20 kg and a radius of gyration, $k_G = 0.18\,\text{m}$. The disk is attached to a spring which has a stiffness k= 40 N/m. The spring has the unstretched length of 0.4 m. The disk is released from rest in the position shown and rolls without slipping and moves 1.2 m to the left. By examining on the above situation,

(a) calculate the elastic potential energy of the spring in the initial and final position.

(6 marks)

(b) determine the angular velocity at the instant G moves 1.2 m to the left.

(14 marks)

-END OF QUESTION-

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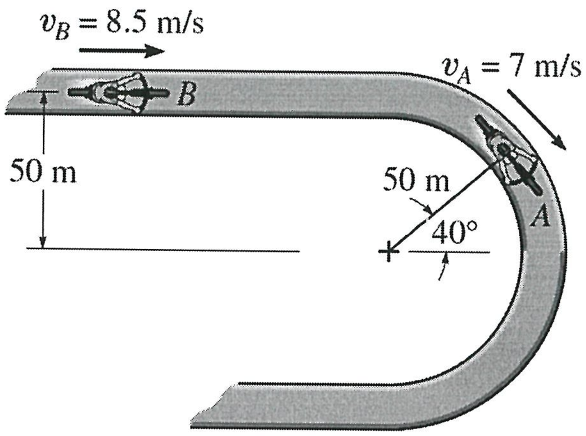

Figure Q1 (b)

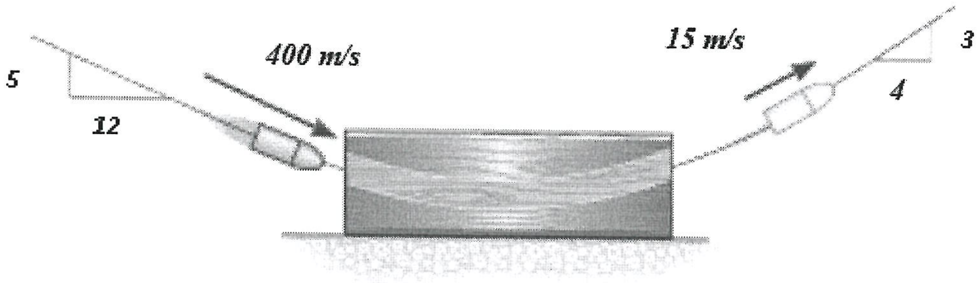

Figure Q2

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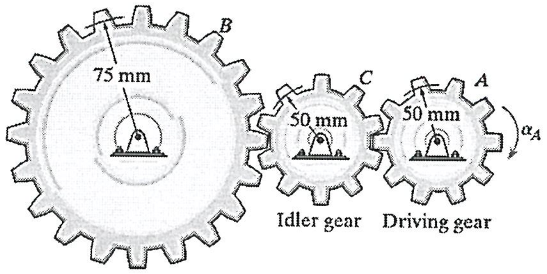

Figure Q3 (a)

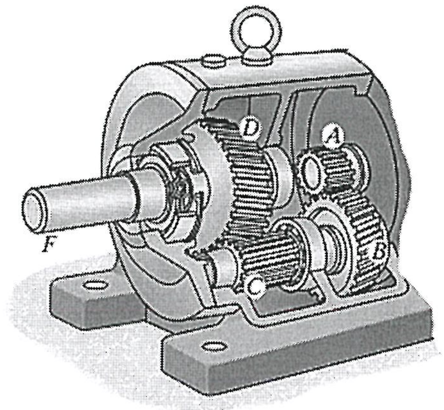

Figure Q3 (b)

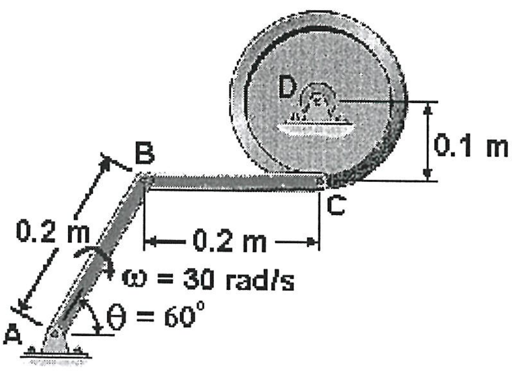

Figure Q4(a)

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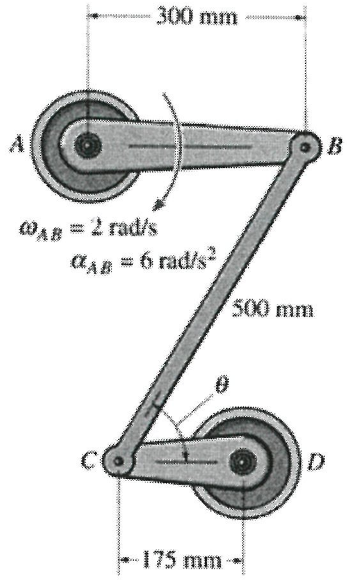

Figure Q4(b)

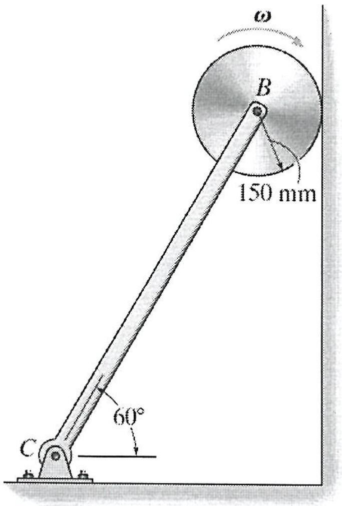

Figure Q5(a)

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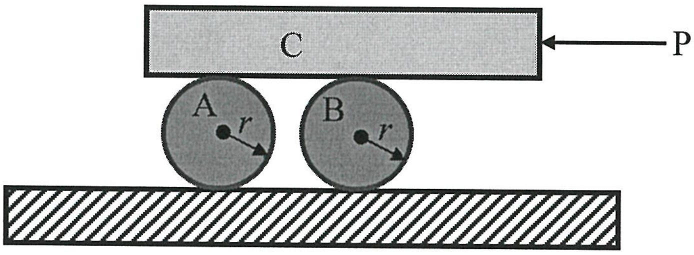

Figure Q5(b)

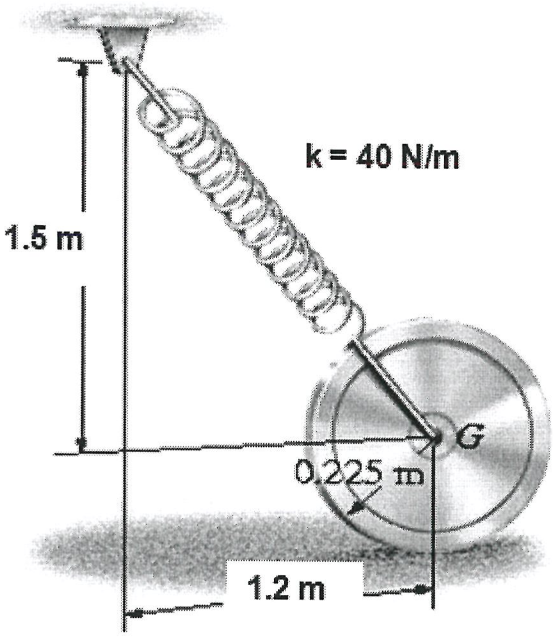

Figure Q6

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KINEMATICS

Particle Rectilinear Motion

Variable a	*Constant $a = a_c$*
$a = dv/dt$	$v = v_0 + a_c t$
$v = ds/dt$	$s = s_0 + v_0 t + 0.5 a_c t^2$
$a\,ds = v\,dv$	$v^2 = v_0^2 + 2a_c(s - s_0)$

Particle Curvilinear Motion

x,y,z Coordinates		*r,θ,z Coordinates*	
$v_x = \dot{x}$	$a_x = \ddot{x}$	$v_r = \dot{r}$	$a_r = \ddot{r} - r\dot{\theta}^2$
$v_y = \dot{y}$	$a_y = \ddot{y}$	$v_\theta = r\dot{\theta}$	$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta}$
$v_z = \dot{z}$	$a_z = \ddot{z}$	$v_z = \dot{z}$	$a_z = \ddot{z}$

n,t,b Coordinates

$v = \dot{s}$ $\quad a_t = \dot{v} = v\dfrac{dv}{ds}$

$a_n = \dfrac{v^2}{\rho} \quad \rho = \dfrac{\left[1 + (dy/dx)^2\right]^{3/2}}{\left|d^2y/dx^2\right|}$

Relative Motion

$v_B = v_A + v_{B/A} \qquad a_B = a_A + a_{B/A}$

Rigid Body Motion About a Fixed Axis

Variable a	*Constant $a = a_c$*
$\alpha = d\omega/dt$	$\omega = \omega_0 + \alpha_c t$
$\omega = d\theta/dt$	$\theta = \theta_0 + \theta_0 t + 0.5\alpha_c t^2$
$\omega\,d\omega = \alpha\,d\theta$	$\omega^2 = \omega_0^2 + 2\alpha_c(\theta - \theta_0)$

For Point P

$s = \theta r \qquad \upsilon = \omega r \qquad a_t = \alpha r \qquad a_n = \omega^2 r$

Relative General Plane Motion – Translating Axis

$v_B = v_A + v_{B/A(pin)} \qquad a_B = a_A + a_{B/A(pin)}$

Relative General Plane Motion – Trans. & Rot. Axis

$v_B = v_A + \Omega \times r_{B/A} + (v_{B/A})_{xyz}$

$a_B = a_A + \dot{\Omega} \times r_{B/A} + \Omega \times (\Omega \times r_{B/A}) + 2\Omega \times (v_{B/A})_{xyz} \times (a_{B/A})_{xyz}$

KINETICS

Mass Moment of Inertia $\quad I = \int r^2 dm$

Parallel-Axis Theorem $\quad I = I_G + md^2$

Radius of Gyration $\quad k = \sqrt{I/m}$

Equations of Motion

Particle	$\sum F = ma$
Rigid Body (Plane Motion)	$\sum F_x = m(a_G)_x \quad \sum F_y = m(a_G)_y$ $\sum M_G = I_G a$ or $\sum M_P = \sum(\mu_k)_P$

Principle of Work and Energy : $T_1 + U_{1-2} = T_2$

Kinetic Energy

Particle	$T = (1/2)mv^2$
Rigid Body (Plane Motion)	$T = (1/2)mv_G^2 + (1/2)I_G\omega^2$

Work

Variable force	$U_F = \int F\cos\theta\,ds$
Constant force	$U_F = (F_c\cos\theta)\Delta s$
Weight	$U_W = -W\,\Delta y$
Spring	$U_s = -(0.5ks_2^2 - 0.5ks_1^2)$
Couple moment	$U_M = M\,\Delta\theta$

Power and Efficiency

$P = dU/dt = F.v \qquad \varepsilon = P_{out}/P_{in} = U_{out}/U_{in}$

Conservation of Energy Theorem

$T_1 + V_1 = T_2 + V_2$

Potential Energy

$V = V_g + V_e$ where $V_g = \pm Wy, V_e = +0.5ks^2$

Principle of Linear Impulse and Momentum

Particle	$mv_1 + \sum\int F dt = mv_2$
Rigid Body	$m(v_G)_1 + \sum\int F dt = m(v_G)_2$

Conservation of Linear Momentum

$\sum(\text{syst. } mv)_1 = \sum(\text{syst. } mv)_2$

Coefficient of Restitution $\quad e = \dfrac{(v_B)_2 - (v_A)_2}{(v_A)_1 - (v_B)_1}$

TERBUKA